

Atty. Docket No. OPP-GZ-2007-0009-US-00
Application No: 10/676,645

Remarks

The present invention relates to a semiconductor device comprising:

- a) a via within an insulation layer over a semiconductor substrate;
- b) a barrier metal layer on a surface of the via;
- c) a metal line consisting essentially of copper in the via over the barrier metal layer having vertical side surfaces that contact the barrier metal layer;
- d) a pad in a predetermined region of the metal line; and
- e) an alloy layer on an upper surface of the metal line having a top surface that is coplanar with or lower than a top surface of the insulation layer and vertical side surfaces that contact the barrier metal layer within the via, wherein the alloy layer consists essentially of copper and a low melting point metal selected from the group consisting of aluminum, lead, and silver (see Claim 1 above).

The cited references do not disclose or suggest, alone or taken together, a semiconductor device including an alloy layer consisting essentially of copper and a low melting point metal selected from the group consisting of aluminum, lead, and silver, on an upper surface of a metal line that consists essentially of copper, where the metal line and the alloy layer have vertical side surfaces in contact with the barrier metal layer. Thus, the present claims are patentable over the cited references.

The Rejection of Claims 1, 4-5, 23-24, 27-32 and 34-37 under 35 U.S.C. § 102(e)

The rejection of Claims 1, 4-5, 23-24, 27-32 and 34-37 under 35 U.S.C. 102(e) as being anticipated by Matsubara (U.S. 6,890,852) is respectfully traversed.

Claim 1 of the present application may be exemplified by a device comprising a metal line 3 consisting essentially of copper in a via 100 over a barrier metal layer 10 having vertical

Atty. Docket No. OPP-GZ-2007-0009-US-00
Application No: 10/676,645

side surfaces that contact the barrier metal layer 10, a pad 200 in a predetermined region of the metal line 3, an alloy layer 5 on an upper surface of the metal line 3 having vertical side surfaces that contact the barrier metal layer 10 within the via 100, wherein the alloy layer 5 consists essentially of copper and a low melting point metal selected from the group consisting of aluminum, lead, and silver (see, e.g., paragraphs [0011]-[0016], and FIG. 1F).

Matsubara discloses a copper thick film 10 and a copper thin film 9 that are comprised within a copper buried wiring 8, which may be made of pure copper or copper alloys (col. 10, ll. 20-22, and FIG. 1). Copper buried wiring 8 may alternatively be composed of copper-Al alloys, copper-Ag alloys, or copper-silicon alloys (see, e.g., col. 10, ll. 20-22). However, Matsubara does not disclose that copper thick film 10 and copper thin film 9 are composed of different materials. Also, amorphous film 29 over copper thick film 10 comprises copper and tantalum (see, e.g., col. 9, ll. 9-28 and FIG. 14), and thus does not represent an alloy layer consisting essentially of copper and a metal selected from the group consisting of Al, Pb, and Ag.

Matsubara also discloses a copper thick film 22 and a copper thin film 21 that are comprised within a copper buried wiring 8, which, like copper buried wiring 8, may be made of pure copper or copper alloys (col. 10, ll. 20-22, and FIG. 12). However, Matsubara does not disclose that copper thick film 22 and copper thin film 21 are composed of different materials. Also, solder layer 27 over copper thick film 22 comprises lead or tin (see, e.g., col. 8, ll. 53-57, and FIG. 12), and thus does not represent an alloy layer consisting essentially of copper and a metal selected from the group consisting of Al, Pb, and Ag.

Therefore, Matsubara is deficient with regard to a metal line consisting essentially of copper in a via and an alloy layer consisting essentially of copper and a low melting point metal selected from the group consisting of aluminum, lead, and silver on an upper surface of the metal line, as recited in Claim 1.

Furthermore, copper thick film 10 does not contact tantalum film 6, which is taught to function as a barrier metal layer, or an amorphous metal film 7 comprising a tantalum-copper alloy, which separates the tantalum film 6 from the copper thin film 9 (see, e.g., col. 3, ll. 16-28; col. 5, ll. 54-60; and Figs. 8 and 12). Thus, Matsubara is deficient with regard to a metal line in a

Atty. Docket No. OPP-GZ-2007-0009-US-00
Application No: 10/676,645

via over a barrier metal layer having vertical side surfaces that contact the barrier metal layer, and an alloy layer on an upper surface of the metal line having vertical side surfaces that contact the barrier metal layer within the via, as recited in Claim 1.

Finally, Matsubara is believed to be silent with regard to a "pad" in a predetermined region of copper buried wirings 8 and 25. It is believed that one skilled in the relevant art would not recognize bump electrode 13 of Matsubara as a "pad" as that term is used in the art (see, e.g., layers 24 and 54 in Liu et al., US 6,638,867, discussed below). Thus, it is believed that Matsubara may be deficient with regard to a pad in a predetermined region of the metal line, as recited in Claim 1.

As a result of the deficiencies explained above, Matsubara does not anticipate the present Claim 1, and the rejection under 35 U.S.C. § 102(e) is not sustainable and should be withdrawn. Claims 4-5, 23-24, 27-32 and 34-37 depend from Claim 1 and thus include all of the limitations of Claim 1. Thus, Matsubara fails to anticipate Claims 4-5, 23-24, 27-32 and 34-37 for at least the same reasons as Claim 1.

The Rejection of Claims 8 and 22 under 35 U.S.C. § 103(a)

The rejection of Claims 8 and 22 under 35 U.S.C. § 103(a) as being unpatentable over Matsubara in view of Liu et al. (US 6,638,867, hereinafter "Liu") is respectfully traversed.

As discussed above, Matsubara is deficient with regard to a device comprising a metal line consisting essentially of copper in a via over a barrier metal layer having vertical side surfaces that contact the barrier metal layer, a pad in a predetermined region of the metal line, an alloy layer on an upper surface of the metal line having vertical side surfaces that contact the barrier metal layer within the via, wherein the alloy layer consists essentially of copper and a low melting point metal selected from the group consisting of aluminum, lead, and silver, as recited in Claim 1.

Liu discloses a bonding pad 60 that includes an aluminum alloy (alternatively copper) bonding pad segment 54 in a shallow interconnection line 40 (see col. 6, ll. 16-27, and FIGS. 6C-

Atty. Docket No. OPP-GZ-2007-0009-US-00
Application No: 10/676,645

6D) and an aluminum conductive layer 58 over the bonding pad segment 54 (see col. 6, ll. 34-42, and FIG. 6C). Liu further discloses that the conductive layer 58 over the bonding pad segment 54 can alternatively consist of aluminum alloy, tungsten, copper, or a copper alloy (see col. 6, ll. 35-40). Liu does not appear to teach or disclose that the non-aluminum metal in the aluminum alloy alternative is copper, or that the non-copper metal in the copper alloy alternative is aluminum (see col. 6, ll. 34-40). Therefore, Liu fails to cure the deficiencies of Matsubara with regard to an alloy layer consisting essentially of copper and a low melting point metal selected from the group consisting of aluminum, lead, and silver, as recited in Claim 1.

Additionally, Liu fails to disclose forming a barrier metal layer in shallow interconnect line 40 (see, e.g., col. 5, ll. 20-36, and FIGS. 5A-5B). Furthermore, conductive layer 58 is not formed within shallow interconnect line 40, and thus would not have vertical side surfaces in contact with a barrier metal layer even if Liu disclosed forming a barrier metal in shallow interconnect line 40 (see, e.g., col. 6, ll. 16-42, and FIG. 6A-6C). Thus, Liu fails to cure the deficiencies of Matsubara with regard to a metal line in a via over a barrier metal layer having vertical side surfaces that contact the barrier metal layer, and an alloy layer on an upper surface of the metal line having vertical side surfaces that contact the barrier metal layer within the via, as recited in Claim 1.

As a result, Liu fails to cure all of the deficiencies of Matsubara with regard to the device of Claim 1. Therefore, Claim 1 is patentable over Matsubara in view of Liu. Claims 8 and 22 depend from Claim 1 and thus include all of the limitations of Claim 1. Thus, Claims 8 and 22 are patentable over Matsubara in view of Liu for at least the same reasons as Claim 1, and the rejection under 35 U.S.C. § 103(a) should be withdrawn.

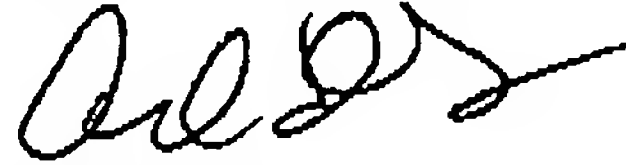
Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

Atty. Docket No. OPP-GZ-2007-0009-US-00
Application No: 10/676,645

If it is deemed helpful or beneficial to the efficient prosecution of the present application,
the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



Andrew D. Fortney, Ph.D.
Reg. No. 34,600

401 W. Fallbrook Avenue, Suite 204
Fresno, California 93711
(559) 432 - 6847

ADF:wkn